HIGH INERTIA GOLF CLUB HEAD

Background of the Invention

Field of the Invention

The present invention relates to golf clubs, and, in particular, to a wood-type golf club head with high inertia.

Description of the Related Art

A wood-type golf club typically includes a hollow shaft with a golf club head attached to the lower end of the shaft. The club head typically includes a load-bearing outer shell with an integral or attached strike plate. The strike plate defines a substantially planar front surface or strike face for striking a golf ball.

The mass of a club head is limited by various practical considerations, such as the desire to keep the swing weight of the golf club close to a conventional value. Accordingly, most club heads have a mass between 180-250 grams. A certain portion of the club head's mass is reserved for components that provide structural support, such as the load bearing outer shell. The remaining mass, which is referred to as performance mass, can be distributed within the club head to optimize performance.

For some time, golf club manufacturers have searched for ways to best distribute the performance weight so as to improve club head performance. Recently, golf club manufactures have attempted to position most of the performance mass along the perimeter of the club head so as to increase the inertia of the club head. In particular, many club heads include two or more weights spaced along the heel/toe axis (i.e., an axis that extends generally parallel to the strike face in a generally horizontal direction). Such perimeter weighting increases the inertia of the club head about the vertical axis. This tends to make the club head more resistant to twisting during off-center hits. However, as will be explained below, such perimeter weighting represents an inefficient use of the performance mass.

An exception to the general trend of heel/toe weighting is U.S. Patent No. 5,176,383, which discloses club head with a weight positioned at the rear of a support.

The support and the weight are in-line with the center of percussion of the club head. This patent claims that this arrangement concentrates the inertial energy of the club head along the center of percussion, which, in turn, maximizes the amount of energy that is imparted to the golf ball. However, a golf club according to this patent disadvantageously has a center of gravity that is above the horizontal centerline of the golf club.

Summary of the Invention

Applicant has developed an improved arrangement for the distribution of the performance mass . Specifically, Applicant recognized that heel/toe weighting does not provide the golf club with the maximum performance characteristics. In particular, heel/toe weighting tends to increase the club head's moment of inertia about two axes: (i) the vertical axis that extends in a generally vertical direction parallel to the strike face and (ii) the front/back axis that extends in a generally horizontal direction perpendicular to the strike face. However, Applicant recognized that during off-center hits the club head tends to rotate about the vertical axis and the heel/toe axis but not the front/back axis. Thus, the moment of inertia about the front/back axis is "wasted".

Accordingly, preferably most and more preferably all of the performance mass of the club head should be arranged so as to increase the club head's moment of inertia about the vertical axis and the heel/toe axis but not the front/back axis. Moreover, it is also important that the performance mass that the center of gravity of the club head lie below the physical center of the golf club. Such an arrangement helps the golfer to get the golf ball airborne. Thus, the performance mass also should be concentrated below the physical center of the club head.

Accordingly, one aspect of the invention is a golf club comprising a strike face and an outer shell that defines an interior volume. The club head has a first moment of inertia about a first axis that extends generally horizontally and parallel to said strike face. The club head also has a second moment of inertia about a second axis that lies generally vertically and perpendicular to the first horizontal axis. The club head also has a center of gravity. The center of gravity is positioned below a horizontal centerline of the club head. The first moment of inertia in units of kilograms millimeters squared ($kg\text{-}mm^2$) is

greater than or equal to approximately 77 plus .46 times the head volume in cubic centimeters (cc).

Another aspect of the present invention is a club head comprising a strike face, an outer shell that defines an interior volume, and a plurality of weights. The plurality of weights are positioned substantially along a front/back axis that extends generally perpendicular from said strike face and are also positioned substantially below a horizontal centerline of said club head.

For purposes of summarizing the invention and the advantages achieved over the prior art, certain objects and advantages of the invention have been described herein above. Of course, it is to be understood that not necessarily all such objects or advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

All of these embodiments are intended to be within the scope of the invention herein disclosed. These and other embodiments of the present invention will become readily apparent to those skilled in the art from the following detailed description of the preferred embodiments having reference to the attached figures, the invention not being limited to any particular preferred embodiment(s) disclosed.

Brief Description of the Drawings

These and other features of the invention will now be described with reference to the drawings of a preferred embodiment, which are intended to illustrate and not to limit the invention, and in which:

Figure 1 is a front view of a golf club centered about a coordinate system;

Figure 2 is a top plan view of a golf club striking a golf ball;

Figure 3 is a side view of a golf club striking a golf ball;

Figure 4 is another side view of a golf club illustrating the location of the center of gravity;

Figure 5 is a front perspective view of the golf club head having certain features and advantages according to the present invention;

Figure 6 is a front view of the golf club head of Figure 5;

Figure 7 is a cross-sectional view of the golf club head of Figure 4;

Figure 8 is a bottom perspective view of the golf club head of Figure 4;

Detailed Description of the Preferred Embodiment

Figure 1 is a perspective view of a club head 10 located about a coordinate system 12. The coordinate system 12 is centered about the center of mass 11 of the club head. As is typical in the art, the club head 10 comprises a strike plate 14, which defines a substantially planar front surface or strike face 16 for impacting a golf ball. A hosel 18 extends upwardly from the strike plate 14. The hosel 18 is used to attach the club head 10 to a golf club shaft (not shown) as is well known in the art. The club head 10 also includes a load bearing outer shell 20 that is either integrally made with or attached to the strike plate 14. A heel region 22 of the club head is located close to the hosel 18 while the toe region 24 of the club head is located opposite the heel region 22.

The coordinate system comprises three axes: (i) a vertical axis 26 that extends in a vertical direction and lies parallel to the strike face 16, (ii) a heel/toe axis 28 that extends in a horizontal direction and lies parallel to the strike face 16, and (iii) a front/back axis 30 that extends in a horizontal direction and lies perpendicular to the heel/toe axis 28.

The club head 10 has a moment of inertia (i.e., a resistance to twisting) about each of the three axes. Specifically, the club head 10 has a moment of inertia about the vertical axis 26 ("Izz"), a moment of inertia about the heel/toe axis 28 ("Iyy"), and a moment of inertia about the front/back axis 30 ("Ixx). The methods for determining these moments of inertia for any particular club head are well known to those skilled in the art.

An aspect of Applicant's invention is the realization that preferably most or more preferably all of the performance mass of the club head should be arranged so as to increase the moment of inertia about the heel/toe axis 28 and the moment of inertia about the vertical axis 26. Figure 2 is a top plan view of a golf ball 32 hitting the face 16

of a club head 10. As is not unusual in golf, the club head 10 is shown striking the golf ball 32 "off-center". In this case, the golf ball 32 has hit the club head 10 near the toe 24 of the club head (i.e., a "side off-center hit"). The off-center side hit causes the club head 10 to twist about the vertical axis 26 as shown by arrow 27A. This tends to produce an inaccurate shot.

To mitigate the twisting about the vertical axis 26 during such off-center side hits, golf club manufacturers have typically sought to increase the golf club's moment of inertia about the vertical axis 26 by concentrating at least some of the performance weight along the heel/toe axis 28. For example, heel/toe weights, which are indicated by the reference number 25, can be added to the club head 10 to increase the club head's moment of inertia about the vertical axis 26. This produces more accurate shots.

However, Applicant realized that such heel/toe weights 25 do not necessarily improve performance during all off-center hits. For example, Figure 3 is a side view of the club head 10 striking a golf ball 32. As with Figure 2, the club head 10 has struck the golf ball 32 off-center. However, in this case, the golf ball 32 has hit the club head 10 below the center of the club head (i.e., a "vertical off-center hit"). This type of off-center hit causes the club head 10 to twist about the heel/toe axis 28 as indicated by arrow 27B. However, heel/toe weights 25 do not increase the club head's moment of inertia about the heel/toe axis 28. Thus, they do not reduce the tendency of the club head 10 to twist about the heel/toe axis 28. Accordingly, heel/toe weights 25 do not improve the golf club's performance during vertical off-center hits. Heel/toe weights do increase the club head's moment of inertia about the front/back axis 30. However, Applicant has determined that during off-center hits the golf club tends not to rotate about this axis. Accordingly, the moment of inertia about the front/back axis 30 is not as effective in improving club head performance.

In contrast, the Applicant recognized that front/back weights 29, which are spaced substantially about the front/back axis, increase the club head's moment of inertia about the heel/toe axis 28. Thus, front/back weights 29 improve the golf club's performance during vertical off-center hits. Moreover, as shown in Figure 2, such front/back weights 29 also increase the club head's moment of inertia about the vertical axis 26. Therefore,

front/back weights 29 improve the club head's performance during side off-center hits and vertical off-center hits.

Another aspect of Applicant's invention is the recognition that the performance mass of the club head should also be arranged such that the club head has a low center of gravity. More specifically, as shown in Figure 4, the center of gravity CG of the club head 10 is preferably located below a horizontal centerline 31 of the club head 10 (i.e., the line 31 that bisects a second line 33, which extends perpendicularly from the ground 35 to the top of the club face 16 when the club head 10 is in the normal address position). In contrast, most golf clubs have a center of gravity above the horizontal centerline 31.

The vertical distance between the center of gravity CG and the horizontal centerline 31 will be referred to as CGz. As mentioned above, a club head 10 desirably has a center of gravity CG that lies below the horizontal centerline 31, which extends through the geometric center 37 of the face. Preferably, the center of gravity lies at least 1 millimeter below the horizontal centerline (i.e., CGz at least 1 mm). More preferably, CGz is 2 millimeters. It is difficult to design wood-type clubs with a center of gravity below the horizontal centerline 31. Accordingly, the front/back weights 29 of the club head 10 preferably are located entirely below the horizontal center line 31 of the club head. Moreover, moving the CG even a small distance below the horizontal centerline 31 has a large effect on the golf shot. For example, failure to get the golf ball air borne results in drastically reduced shot distance. A low center of gravity helps the golfer get a golf ball air borne. Specifically, a lower center of gravity increases the launch angle of a golf shot because when the center of gravity is below the point of impact the club face 16 rotates in such away that it increases the loft of the golf ball.

The club head preferably should also be arranged such that the center of gravity is located not too far back from a shaft or hosel axis 37 of the club head 10 (i.e., a line that extends through the center of the shaft and the hosel). The horizontal distance in a direction back from the face 16 between the center of gravity and shaft or hosel axis 37 will be referred to as Delta1. Preferably, Delta1 is in the range of 12 - 25 millimeters. More preferably, Delta1 is in the range of 16-20 millimeters. Most preferably, Delta 1 is in the range of 17 -18 millimeters. Delta 1 can be manipulated by varying the mass in

front of the center of gravity (i.e., closer to the face) with respect to the mass behind the center of gravity. That is, by increasing the mass behind the center of gravity with respect to the mass in front of the center of gravity, Delta1 can be increased. In a similar manner, by increasing the mass in front of the center of gravity with respect to the mass behind the center of gravity Delta1 can be decreased. The above ranges for Delta1 are preferred for several reasons. If Delta1 is too far forward, the trajectory of the golf ball tends to be too low and to the right, especially in large club heads (e.g., an interior value greater than 300 centimeters cubed). Conversely, if Delta 1 is too far back the trajectory of the golf ball tends to be too high and the golf ball tends to have too much spin.

With reference now to Figures 5-8 a preferred construction of a golf club head 50 with certain features and advantages according to the present invention will now be described. As shown in Figure 5, the club head 50 is comprised of a strike plate 58. The strike plate 58 defines a substantially planar front surface or strike face 60 for impacting a golf ball. A hosel 62 extends upwardly from the strike plate 58. The hosel 62 is configured to be coupled to a golf club shaft (not shown) in a well known manner. The strike plate 58 and hosel 62 are preferably made of a strong yet light weight metal, such as titanium or a composite material. Of course, other suitable materials can be used.

The club head 50 further comprises a load bearing outer shell 64 that is preferably attached to the strike plate 58. As with the strike plate 58, the outer shell is preferably made of a strong yet light weight metal, such as, for example, titanium or a composite material. Of course, other suitable materials can be used. The outer shell 64 preferably defines an interior volume 65 (see Figure 7) of the club head. Together the strike plate 58 and the outer shell 64 define a head volume (i.e., "HV") of the club head 50. The head volume HV represents the volume occupied by the club head 50 and is traditionally measured in cubic centimeters (i.e., "cc"). Head volume is an important design parameter. Other things being equal, it is easier to achieve a higher moment of inertia in a club head that defines a larger head volume as compared to a club head that defines a smaller head volume. This is because the performance weight can be distributed farther from the center of club in a club head with a large head volume. Conversely, other things being equal, it is easier to achieve a lower center of gravity in a club head with a small head volume as compared to a club head with a large head volume. Accordingly, a design compromise

must be made between desired inertial characteristics of the club head and the location of the CG. Moreover, golfers generally do not like the look and feel of unusually large or small club heads. Thus, the head volume 65 of the club head 50 preferably is between 200 - 450 cubic centimeters.

With reference to the front view of Figure 6, the club head 50 includes a toe region 66 and a heel region 68, as will be known to those of skill in the art. The bottom of the club head is delimited in part by a sole 70 and the top of the club head is delimited by a crown 72. The features of the club head 50 described up to this point can be considered conventional.

Golfers prefer a driver golf club to have a total mass less than 250 grams. Therefore, the club head 50 preferably has a total mass less than 250 grams. More preferably, the club head has a total mass less than 230 grams. Most preferably, the club head has a mass less than 210 grams. A lighter club head 50 is preferred because it reduces the swing weight of the golf club. However, a lighter club head also has less performance weight available to increase the moment of inertia of the club head 50. Thus, a design compromise must be made between the total mass of the club head 50 and the desired inertial characteristics of the club head.

The structural members (i.e., the outer shell 64 and the strike plate 58) have mass of approximately 60% - 90% of the total mass of the club head 50. The remaining 40% - 10% of the club head mass constitutes the performance mass, which is preferably distributed in the weight plugs 74 described below.

Figures 7 and 8 show cross-sectional side and bottom views, respectively, of the club head 50. In the preferred embodiment, the golf club head 50 includes two or more weights plugs 74a, 74b that are situated within corresponding recesses 76a. 76b formed in the outer shell 64. In the illustrated embodiment, the weights 74 are removably coupled to the sole 70 of the club head 50 by screws 78. However, it should be appreciated that the weights 74a. 74b can be coupled to the club head 50 by using an adhesive, brazing, etc., or the weights 74 may be integrally formed with the sole plate. The weights 74a. 74b preferably are made of a material, such as, for example, tungsten, that is denser than the material(s) that form the outer shell 64 and the strike plate 58.

As best seen in Figure 8, the weights 74a, 74b are preferably located along a front/back axis 80 that extends generally perpendicularly away from the strike face 60 of the club head 50. More preferably, one of the weights 74a is located along the front back axis 80 near the strike plate 58 and the other weight 74b is also located along the front back axis 80 near a rear end 81 of the club head 50.

In addition, as best seen in Figure 7, both of the weights 74a, 74b are preferably also located below the horizontal centerline 82 of the club head 50. This arrangement is preferred because it moves the center of gravity of the club head 50 to a position below the horizontal centerline 82.

The club head described above 50 preferably has a moment of inertia about the heel/toe axis that is significantly greater than conventional club heads (i.e., interior volumes between 200-350 centimeters cubed and a mass between 180-250 grams). As mentioned above, the inertial properties of a club head are dependent upon the head volume. Accordingly, the club head 50 preferably has a moment of inertia through the center of gravity about the heel/toe axis as set forth below in equation 1.

$$Ixx \geq .46 * HV + 77 \qquad (1)$$

where: HV = cubic centimeters (cc)
Ixx = kilogram millimeters squared ($kg\text{-}mm^2$)

More preferably, the club head 50 has a moment of inertia through the center of gravity about the heel/toe axis is as set forth in equation 2.

$$Ixx \geq .46 * HV + 107 \qquad (2)$$

where: HV = cubic centimeters (cc)
Ixx = kilogram millimeters squared ($kg\text{-}mm^2$)

The higher moments of inertia of equation 2 can be achieved by reducing or holding constant the mass of the shell 64 and/or the strike plate 58 while increasing or holding constant the mass of the weights 74a, 74b while also giving due consideration to the structural integrity of the club head 50.

In addition, the center of gravity of the club head 50 preferably lies below the horizontal centerline 82 of the club head 50. More preferably, the center of gravity is greater than 1 millimeter below the horizontal centerline 82 of the club head 50. The lower center of gravity can be achieved by increasing the mass of the weights 74a, 74b

while reducing or holding constant the mass of the shell 64 and strike plate 58. The center of gravity can also be reduced by decreasing the thickness of the weights 74a, 74b and/or decreasing the density of the weights 74a, 74b.

Preferably, the club head 50 also has a moment of inertia about the vertical axis that is at least 250 kilograms per millimeter squared. More preferably, the club head has a moment of inertia about the vertical axis of at least 300 kilograms per millimeter squared. As with the moment of inertia about the heel/toe axis, the moment of inertia about the vertical axis can be increased by reducing or holding constant the mass of the shell 64 and/or the strike plate 58 while increasing or holding constant the mass of the weights 74 while also giving due consideration to the structural integrity of the club head 5

As mentioned above, the Delta1 of the club head 50 preferably is less than 30 millimeters. Preferably, Delta1 is in the range of 12 - 25 millimeters. More preferably, Delta1 is in the range of 16-20 millimeters. Most preferably, Delta 1 is in the range of 17 -18 millimeters.

The club head 50 described above has generally traditional dimensions as a driver-type wood (i.e., the head volume is between 300 and 200 centimeters cubed). However, some golfer prefer a "large" club head. That is, some golfers prefer a club head that defines an interior volume greater than 300 centimeters cubed and a mass between about 180-210 grams . If such a club head is desired, it can be constructed as described above by enlarging the size of the strike plate 58 and the outer shell 64.

As with the club head 50 described above, the club head 50 preferably has a moment of inertia about the heel/toe axis as set forth above in equation 1. More preferably, the club head 50 has a moment of inertia about the heel/toe axis as set forth in equation 2. The center of gravity of the club head also preferably lies below the horizontal centerline 82 of the club head 50. More preferably, the center of gravity is greater than 1 millimeter below the horizontal centerline 82 of the club head 50. Preferably, the club head 50 also has a moment of inertia about the vertical axis that is at least 250 kilogram millimeters squared ($kg\text{-}mm^2$). More preferably, the club head has a moment of inertia about the vertical axis of at least 300 kilogram millimeters squared ($kg\text{-}mm^2$). Preferably, Delta1 is in the range of 12 - 25 millimeters. More preferably, Delta1 is in the range of 16-20 millimeters. Most preferably, Delta 1 is in the range of 17 -18 millimeters.

In a modified arrangement, the head may comprise a smaller driver or a fairway wood club head. This smaller club head defines an interior volume less than 200 centimeters cubed and a mass between about 200-250 grams. If such a club head is desired, it also can be constructed as described above by adjusting the shape and size of the strike plate 58 and the outer shell 64. As with the club head 50 described above, the club head 50 preferably has a moment of inertia about the heel/toe axis as set forth above in equation 1. More preferably, the club head 50 has a moment of inertia about the heel/toe axis as set forth in equation 2. The center of gravity of the club head also preferably lies at least 1 millimeter below the horizontal centerline 82 of the club head 50. More preferably, the center of gravity is greater than 2 millimeters below the horizontal centerline 82 of the club head 50. Preferably, the club head 50 also has a moment of inertia about the vertical axis that is at least 200 kilogram millimeters squared ($kg\text{-}mm^2$). More preferably, the club head has a moment of inertia about the vertical axis of at least 250 kilogram millimeters squared ($kg\text{-}mm^2$). Delta1 preferably is in the range of 12 - 25 millimeters. More preferably, Delta1 is in the range of 16-20 millimeters. Most preferably, Delta 1 is in the range of 17 -18 millimeters.

For purposes of describing the invention and the advantages achieved over the prior art, certain objects and advantages of the invention have been described above. Of course, it is to be understood that not necessarily all such objects or advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

Moreover, although this invention has been disclosed in the context of certain preferred embodiments and examples, it will be understood by those skilled in the art that the present invention extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof. In addition, while a number of variations of the invention have been shown and described in detail, other modifications, which are within the scope of this invention, will be readily apparent to those of skill in the art based upon this disclosure. It

is also contemplated that various combination or subcombinations of the specific features and aspects of the embodiments may be made and still fall within the scope of the invention. Accordingly, it should be understood that various features and aspects of the disclosed embodiments can be combine with or substituted for one another in order to form varying modes of the disclosed invention. Thus, it is intended that the scope of the present invention herein disclosed should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims that follow.